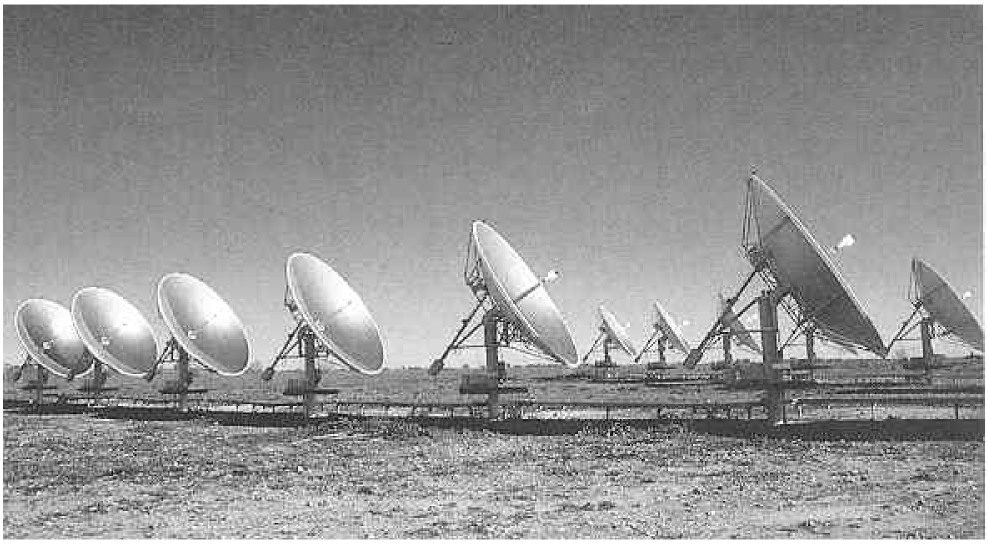
Nomination Report

Australian Historic Engineering Plaquing Program
A Historic Engineering Marker (HEM)
for

White Cliffs Solar Power Station
(1981)



Early Photograph from Energy Authority of NSW Annual Report (1983)

Prepared by: Chris Dalitz

For the Heritage Committee - Sydney Division
24th July 2006

APPENDIX A

Nomination Form

Australian Historic Engineering Plaquing

The Administrator
Engineering Heritage Australia
The Institution of Engineers, Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: **White Cliffs Solar Power Station** ....

The above-mentioned work is nominated to be awarded a:
~~National Engineering Landmark*~~: ....

- Historic Engineering Marker*: ....

* (Delete as appropriate).

Location, including address and map grid reference if a fixed work:

White Cliffs, NSW...

Owner: **Country Energy** ....

....

The owner has been advised of this nomination, and a letter of agreement is attached.

Access to site: **The White Cliffs Solar Power Station is easily identified by any visitor to the town, being clearly visible from the road into town. It is proposed to erect the HEM plaque on a suitable local rock just inside the personnel entry gate, so it is visible at all hours. Conducted tours of the facility can be arranged through a local tour operator.**...

....

Nominating Body: **Heritage Committee-Sydney Division**...

Glen Rigden ....
Chair of Nominating Body

Date: 24 July 2006 ....

Chair of Division Engineering Heritage Group

Date: ....

APPENDIX B

Engineering Heritage Australia

Plaquing Nomination Assessment Form

Please complete as many items as possible, but leave blank any for which the information is not available, or would involve considerable research).

1. BASIC DATA

Item Name: White Cliffs Solar Power Station

Other/Former Names: Not Applicable

Location (grid reference if possible): Township of White Cliffs in far western NSW approximately 90kms north of Wilcannia or 250 kms north east of Broken Hill.

Address: White Cliffs, NSW

Nearest Towns: Wilcannia, Broken Hill.

State: NSW

Local Govt. Area: Central Darling Shire Council

Owner: Country Energy (former owners were Australian Inland, Broken Hill Electricity and its successors , and earlier the NSW State Government - Energy Authority of NSW and its successors)

Current Use: The White Cliffs Solar Power Station ceased generating electricity into the Grid in January 2005. It is currently still in operable condition, but the dishes are ‘parked’ and locked in a position away from the sun to prevent glare or accidental damage. The facility is primarily being used as a tourism and educational facility. It is also used as a remote depot and emergency store for Country Energy staff operating out of the Wilcannia Field Service Centre.

Former Use (if any): The White Cliffs Solar Power Station generated electricity from sunlight from January 1982 till January 2005, using two quite different solar technologies. It was arguably the first commercial solar power station in the World.

Designer (s): Team of Researchers led by Professor Stephen Kaneff (Australian National University) The ANU formed a commercial company (ANUTECH Pty Ltd) to handle the project.

Maker/Builder(s): As above, assisted by various sub-contractors, consultants and locals at White Cliffs. (including Mertz & McLellan-Sydney, Davy Pacific-Melbourne, and Environ Mechanical Services-Sydney).

Year Started: 1981(Construction) **Year Major Upgrade:** 1997

Physical Description: (original 1981 thermal system)

The original power station was established by ANU researchers as an experimental facility with funding from the NSW State Government (Energy Authority of NSW). Construction commenced in 1981 and the final cost totalled nearly $1.9 million. The power station comprised fourteen sun tracking parabolic dishes of 5 metres diameter (two rows of seven), each concentrating the suns rays onto a thermal absorber at its focal point to heat water to produce steam. The steam was piped back to a central heat exchanger to power a reciprocating steam engine generator that produced up to 25kW of electricity. Some of the energy was stored in batteries (to provide electricity at night) and a back-up diesel generator ensured supply during extended cloudy periods.

The electricity from the station was reticulated at low voltage (240 volts) over a limited area of the township, supplying the local hospital, school, post office and twelve homes. Because this electricity was 'sold' to these customers, this gives rise to the claim that White Cliffs was the "first commercial solar power station in the world". At the time there was no grid supply to White Cliffs and electricity was otherwise generated at individual dwellings by diesel generators.

Like all experimental facilities, particularly those with multiple mechanical systems and pumped liquids, there were many problems encountered. The thermal stress of metal components, particularly the absorbers at the focus of the dish concentrators, often resulted in leaks occurring in pipework. The auxiliaries (pumps, motor drives for the mirrors, battery chargers, lighting etc) all consumed electricity themselves, to the extent that these loads often exceeded the output of the electric generator. Hence, the diesel generator was often required to run, and its output often exceeded the consumption of the connected customers (ie it was more efficient to turn the solar system off). This situation was the result of the small size of the experimental solar station, in a larger system the auxiliaries would be a smaller fraction of the station output.

However, the facility did demonstrate the technology, and proved electricity could be generated from sunlight and supply a remote community, even if not very economically. When the grid supply was extended to White Cliffs, and replaced the need for the diesel back-up, the economics of the facility improved.

Physical Description : (1997 photovoltaic system)

In 1997, the facility was converted to a photovoltaic system. The dishes were re-surfaced with new mirror panels and the thermal absorbers were each replaced by a cluster of 16 photovoltaic cells which were more than 22% efficient in converting solar radiation directly into electricity. Water circulation was still required at the focal point to cool the photovoltaic cells and maintain their efficiency.

The new system produced up to 42kW peak output, which was fed directly into the electricity grid (which now supplied the township), removing the need for batteries and the diesel backup. New software improved the tracking of the dishes by predicting the suns position and allowed for local or remote monitoring and control.

In its last full year of operation (2003-2004) the power station generated 35,412 kWh of electricity.

Physical Condition:

Excellent. Virtually all the 1997 system is still in situ, and remnants of the original thermal system have been retained on site, including the thermal generator, pipe work, battery shells. An educational/interpretive display is still in place, but the AV and models are no longer operational.

Modifications and Dates: see above

Historical Notes:

Timeline

Date	Description
Mid 1979	White Cliffs selected as location for Station
Aug 1980	ANU finalise design configuration
May 1981	Off site construction completed
Dec 1981	On site construction completed
Jan-Jun 1982	System Testing, station then operates on ‘dummy’ load
30 Nov 1983	Station ‘handed over’ to Energy Authority
April 1984	The Chlorothene Experience
March 1991	Research Report Published by Office of Energy
1997	Solar Systems convert station to Photovoltaic
Jan 2005	Station ceases generating

On the difficulties of a project at a remote site…(from 1991 Research Report)

“Travel to the site involved little fuss while installation was carried out, but subsequently became a saga during check-out and commissioning, due mainly to the problems met with engine development. The writer made some 100 trips over the first 7 years, each involving a return journey of 2 200 km, often at night and driving (within 600 km of White Cliffs) in the midst of what always seemed to be an endless stream and variety of animals feeding or congregating at the roadside, where the meagre rainfall is concentrated due to run off, causing a presence of the only greenery in the area during drought years, especially 1981-83 and 1985-86. Animals run down by passing vehicles provide food for another group of animals and birds; the whole presenting a profoundly moving spectacle of what might be described as a roadside ecosystem involving not only indigenous life but also imported species such as foxes, and (stray) sheep, cattle and horses.

On 24 October 1979 (the first site visit) the writer and a colleague were astonished to see, over the final stretch of some 100 km of road in mid-morning, a succession of reptiles which must have represented nearly the full reptile repertoire of the region, with a density of one every few tens of metres, a sight not observed before or since. Volumes could be written on these episodes and generally on the spectacular sunsets, the rich natural life. the harshness of existence and the extremely interesting people in the region.”

The Chlorothene Experience…(from 1991 Research Report)

‘In April 1984 operators at the station noticed that chlorothene, which was available as a cleaning agent preferable to carbon tetrachloride, produced a magical elimination of the colloidal oil suspension in a sample of feedwater and added a litre of chlorothene to the feedwater tank. The oil-water treatment system became perfect in producing crystal clear feedwater.

Within 3 days all- the solar absorbers had sprung multiple very fine pinhole leaks in the region where water turns to wet steam and it was found that the engine valve mechanism was, also affected even though, when problems were suspected. Very stringent steps had been taken to flush the chlorothene-carrying feedwater from the system. The well known effect of even very small quantities of chlorine when combined with oxygen and boiling water on stainless steel was not suspected as a factor; in the event, chromium was removed and numerous small pinholes resulted in the absorber coils in the boiling water zone, all within a relatively short time. This failure of communication between system designers and operator was unfortunate, and served to tighten general operation and maintenance procedures. All absorbers had to be replaced, the system flushed very carefully, engine valves replaced, and the engine oil flushed and replaced - a time-consuming exercise.

This episode served as a warning about operating procedures and uninformed decisions on system matters being taken. It also cleared up a nagging unexplained problem which had occasionally intruded to cause some absorbers, after a relatively short time (weeks), to develop multiple pinhole faults in the region where water changes to wet steam. With the above lesson in mind, we discovered that sometimes a more than usually diligent craftsman had cleaned out the inside of wound absorbers produced in our workshop with chlorothene, without this being specified, notified or noticed at the time. A few parts per million of chlorine are adequate to cause problems with stainless steel.”

2. ASSESSMENT OF SIGNIFICANCE

Historic Phase:

The original system was designed to make use of a Rankine Cycle Uniflow steam engine from T Pritchard of Melbourne, who had 25 years of steam car engine experience, and had recently (in 1979) been awarded Commonwealth funding to continue development of his engines. A Pritchard engine turned out not to be available, and an alternative engine was supplied by Commander G Vagg, a steam specialist with the Australian Navy, and another steam car enthusiast.

Historic Individuals or Association:

Emeritus Professor Stephen Kaneff

Emeritus Professor Stephen Kaneff in front of the $400m^2$ 'Big Dish' at the Australian National University. Professor Kaneff's research over the last 30 years on solar thermal concentration has formed the basis for several promising developments in solar thermal electricity generation.

From: Australian Energy News-June 1998

The Australian National University (ANU) and in particular ANUTECH Pty Ltd which was established by the Uni specifically for this project.

Environ Mechanical Services (Melbourne) -prepared the feasibility and project assessment in 1979 for ANUTECH.

Davey McKee Pacific (Melbourne) – heat transfer systems

Merz and McLellan and Partners (North Sydney) prepared a 1980 Report for ANUTECH

Mr Alan Frost (formerly of SMEC) prepared a review for the Energy Authority in 1982, as did Prof. JR Glastonbury, (Dean of Engineering at the University of Sydney) in 1985.

White Cliffs locals, Peter Thompson (who became the first Station Operations Manager), Graham Wellings, and Bill Finney (now at Broken Hill, who was also Station Manager for many years)

Mr Maurice Overy and Mr Mal Williams of the Department of Energy and Utilities (DEUS) who were both with the Energy Authority at the time (Mal was present at the handover on 30th Nov 1983).

Jones and Rickard of Sydney supplied the custom built 37kVA AC generator which was 92% efficient from 25% to full load.

Solar Systems (www.solarsystems.com.au) converted the station to photovoltaic in 1997 and operated the station up until January 2005.

Creative or Technical Achievements:

The following is taken directly from the 1991 Research Report :-

6.1 Achievements

1. The station supplies White Cliffs with electrical power with an overall reliability not inferior to that applying on the NSW grid. The system overall and its components are improving as remaining outstanding matters are resolved.
2. The station works on a continuous stand-alone basis, the only such installation of which we are aware. Experience now shows a decreasing O&M component; this O&M can be handled by local people.
3. In view of (2) above, we consider the technology is very suitable for the application.
4. Objectives of the project have been met - the necessary information and scientific, technological and economic data and understanding have been attained.
5. Of its generation, it was by far the cheapest on a per unit basis.
6. Development from conception through the research, development, experimentation and useful supply stages had been achieved largely in one step.
7. Cost potential for the next generation units and the nature of these units have been revealed and appear attractive, pointing to competitive viability with diesel sets in appropriate areas.
8. The concepts selected and the underlying principles have turned out to be very successful and need not be changed.
9. Many parts of the system have involved original development of significance for future work; they have a wider application in their own right. For example,
   - Rotary joints for conveying simultaneously hot and cold fluids via the two axes of rotation.
   - A special skimmer for removing surface (floating) oil from the feedwater.
   - A simple reliable automatic torque balancing system.
   - A simple system for enabling energy flow control between the various parts of the system.
   - And others.
10. We have the most real-world operating hours of any solar thermal system of which we are aware.
11. The technology developed is `appropriate for relatively unsophisticated production and running'.
12. The project has highlighted the value of going out into the field at an early stage in order to experience and understand the realistic situation and to develop design appropriately.

13. A good awareness (and statistical data) has been developed of the nature, extent and influence of environmental effects. Effect of solar radiation on materials has been most remarkably demonstrated, revealing unexpected weaknesses and strengths which provide valuable lessons for future systems. Good understanding of the approaches necessary to run solar steam systems has been attained.

    Hitherto unavailable design data has been acquired; a set of design strategies as well as O&M constraints and strategies has been assembled; design parameters for effective operation have been revealed.

14. It has been demonstrated that an array of collectors working on a modular basis can be operated successfully, whether for electricity generation or industrial process heat; modules can be removed from service for attention without upsetting the rest of the system or its integrity.

    Because of this modularity, although the results have been attained on a relatively small system, they carry over to much larger systems.

15. It has become very clear that dish sizes must be increased greatly (say to 300 m^2 aperture) in order to adequately increase economic viability when economy of size, as in most systems, becomes well apparent. Cost analyses of such dishes appear very at tractive, targeting a cost per square metre of $150 Australia. In these circumstances, industrial process heat may become available in sunny areas for some 0.6¢/MJ or 2¢ per kWh thermal.
16. The project has resulted in development of a very successful high performance steam engine whose application areas seem extensive. Such an engine, when combined with a large dish (as in (15) above), may produce electricity at less than 20¢ per kWh on a production basis.
17. The White Cliffs Project is well known overseas; this has produced tangible benefits through the desire for close collaboration, as indicated below.
18. We consider it is now likely that settlements without existing grids can be supplied reliably and economically with solar thermal power, this being a more appropriate approach. Settlements on the grid, but at the end of long lines, might also well benefit from such solar power.
19. The project has already resulted in several `spinoffs' including:

    - Interest generated in our dishes at the 1982 World's Fair - Energy Expo. Knoxville Tennessee, May to November 1982. The Department of Works built two of our dishes and mounted these in front of the Australian Pavilion.
    - We are collaborating with the University of the South Pacific (Suva) on producing a rural village power supply using our engine and probably dishes/wind enhancement. Crop wastes may be suitable to raise steam.
    - At the request of the Maryborough (VIC) Council, we set up one of our 5 metre dishes for ascertaining the feasibility of supplying the hospital with low quality steam.
    - At the request of the Lizard Island (northern Australia) Research Station of the Australian Museum„ we established in 1984 a solar/wind monitoring

station preparatory to designing a dish/engine system for the island (if climatic conditions prove suitable).

- At the instigation of Allco Steel of Tomago (NSW), we are collaborating with a view to developing large dishes and other technology for the utilization of high temperature solar energy.
- The solar firm Power Kinetics Inc (Troy NY) has been granted a licence to market the ANU engine technology for solar and other applications, recently purchased from us an improved engine which they intend to use
- At the invitation of Power Kinetics Inc, we put in a joint bid to the CS Department of Energy for the Molokai Solar Power Station. Our joint bid was successful and the project (engines supplied by us and collectors supplied by Power Kinetics) successfully completed tests at the US Department of Energy test site in Albuquerque (New Mexico) in August 1988.
- The considerable perceived versatility of our engine has also resulted in other projects being considered, taking advantage of its cogeneration possibilities, waste heat, waste crop and fuel utilization, direct solar water pumping and remote area-power supply

The 1997 "refit" by Solar Systems, using photovoltaic clusters at the focal point of the re-surfaced dishes, again drew upon research from the Australian National University. Control systems, data logging etc had considerably advanced, and the facility was remotely monitored by Solar Systems using a modem.

Again, White Cliffs demonstrated an array of sun tracking parabolic dishes could commercially generate electricity, this time using direct conversion to electricity with a cluster of cells at the focal point of the dishes. The introduction of 'renewable energy certificates' or REC's in the context of a National Electricity Market, and the Mandatory Renewable Energy Target (MRET) set by the Federal Government, as well as accredited "Greenpower" schemes offered by energy retailers, meant that energy generated at White Cliffs could be "sold" at a premium.

In the "re-vamped" installation, water was used as a 'coolant', rather than being heated. Once again, leaks in the water system were an 'annoyance', particularly for what was normally an un-manned facility, and as more and more "patches" were added.

Ultimately, as with the solar thermal technology, the "economy of scale" from the relatively small 5 metre dishes again became a limiting factor for the station, and Solar Systems withdrew from the project early in 2005, to concentrate on their 'big dish' systems elsewhere in Australia.

Research Potential:

The White Cliffs Solar Power Station was essentially established as a research facility and demonstration project, and continued in that role throughout its operation and various upgrades and evolutions.

Being essentially operational, the Power Station could continue to offer research opportunities, should a University or private company be interested in approaching Country Energy.

As an example, here is an extract from the 1991 Research Report :-

“The remoteness of the site…has allowed other research….a group from the Physics Department of the University of Adelaide has been using three of the solar array (dishes) at the vertices of the largest triangle available on the array, for gamma ray astronomy at night, replacing the usual solar receivers with special sensors”.

Social:

The White Cliffs Solar Power Station has become an ‘icon’ of the township, and is often used as an identifying symbol of the township. The fact the original station supplied electricity to the community, at a time when grid supply was not available, gives it particular social significance.

White Cliffs is a small community, and many observed, or were directly involved with the construction, maintenance and operation of the station. Many of these people are still in White Cliffs.

Rarity:

The White Cliffs Solar Power Station was certainly the first of its type in Australia, if not the World, and remains one of the few Solar Dish type facilities in Australia. More recent examples utilise fewer but larger dishes, so White Cliffs remains unique in Australia because of its number of dishes (fourteen).

The following is taken from the 1991 Research Report.

“The White Cliffs system configuration used is only one of a vast number of alternatives which can be identified as potentially suitable candidates for the production of high quality solar-derived heat and its conversion to work and electricity, with a wide range of alternative components differing in form and function, being suggested. But we know even now (July 1987) of only five working paraboloidal dish arrays, each employing different approaches, for which there is any accumulated operating experience so far - the White Cliffs station generating electricity; the MBB-Kuwait station for electricity generation/water pumping and water desalination [Zewen and Co-Workers 1983, Moustafa and Co-Workers 1983]; the Shenandoah, Georgia, system for electricity generation and the provision of industrial heat [Ney and King 1984]; the La Jet 5 MW electricity generation plant [Schefter 1985, McGlaun 1987] at Warner Springs, California; and the Power Kinetics Inc 18-dish array in Saudi Arabia for water desalination (Krepchin and Co-Workers, 1987).

Several developments are at different stages of completion/commissioning/design, and involve single dish/engine units, notably the Advanco Dish/Stirling system at Indian Wells, California; the McDonnell Douglas Dish/Stirling modules (Colemand and Raetz, 1986) and others.

While common features in existing and proposed paraboloidal dish systems may be identified, it would be inappropriate to claim that anything like common principles and philosophies with respect to design have emerged, let alone standardized key hardware components. Each system has been a special study designed to reveal the characteristics and viability of a particular approach, selected from many alternatives. There seems as yet no conventional dish array to serve as a guide to further developments; and it may take some time for such to emerge. Suffice to remark that a great deal of research and development on dishes, engines and systems is currently ongoing.”

TABLE XXI— SOME NOTEWORTHY SOLAR ELECTRIC SYSTEMS

SYSTEM	LOCATION	WHEN FIRST OPERATING	SIZE	TYPE*	COST $/W (PEAK)
Barstow	California USA	1982	10 MW	CR	$US 14.4/W
White Cliffs	NSW Australia	1982	25 kW	PD	$A 9/W (no backup) $A 12/W (storage and backup)
Arco	Hisperia CA	1984	1 MW	PV	$US 12/W
	Carissa Plains CA	1984	6 MW	PV	$US 8/W (?)
LUZ	California USA	1984/86	13 MW	PT	$US 5.5/W
	"	1986	30 MW	PT	$US 4.5/W
	California USA	1987	30 MW	PT	$US 3.2/W
La Jet	California USA	1984/85	5 MW	PD	$US 2.8/W
Power Kinetics		Full Design Study	10 MW	PD^+	$US 1.35/W (expected)
ANU	N.S.W.Australia	1991 Experimental	50 kW	PD^+	$A 2/W (expected)

* CR = Central Receiver; PD = Paraboloidal Dish; PV = Photovoltaic; PT = Parabolic Trough.

Representativeness:

Unique in Australia and one of only a few Worldwide – see comments and Table above.

Integrity/Intactness:

Excellent. Virtually all of the 1997 system is still in situ, and remnants of the original thermal system have been retained on site, including the steam powered generator, pipe work, battery shells etc. An educational/interpretive display is still in place, but the AV and models are no longer operational

Statement of Significance:

The White Cliffs Solar Power Station is believed to be the first commercial solar power station in the World, and is certainly unique in Australia. Conceived in the 1970's and built in 1981, the station provided electricity to a remote community that was not connected to the electricity grid. Solar Stations built elsewhere in the World around this time were primarily for research only, or for water de-salination. Whilst White Cliffs was also a research facility, the electricity output was sold to the local community, hence giving rise to its claim as the World's first commercial solar power station.

Both the original thermal system, and the 1997 photovoltaic conversion, demonstrated that solar power was a viable option for electricity generation, albeit at a price premium. Both systems were at the 'leading edge' of their respective technologies of the time, and contributed significant research benefits to their respective developers. (ANUTECH and Solar Systems).

In addition to its engineering and scientific significance, the White Cliffs Solar Power Station is also of social significance. The station quickly became an 'icon' for the town of White Cliffs, and continues to attract visitors from around the World as a tourist attraction.

Assessed Significance: State

Plaque Wording Proposed (DRAFT) :-

The citation for this historic engineering marker to read as follows…….

WHITE CLIFFS SOLAR POWER STATION

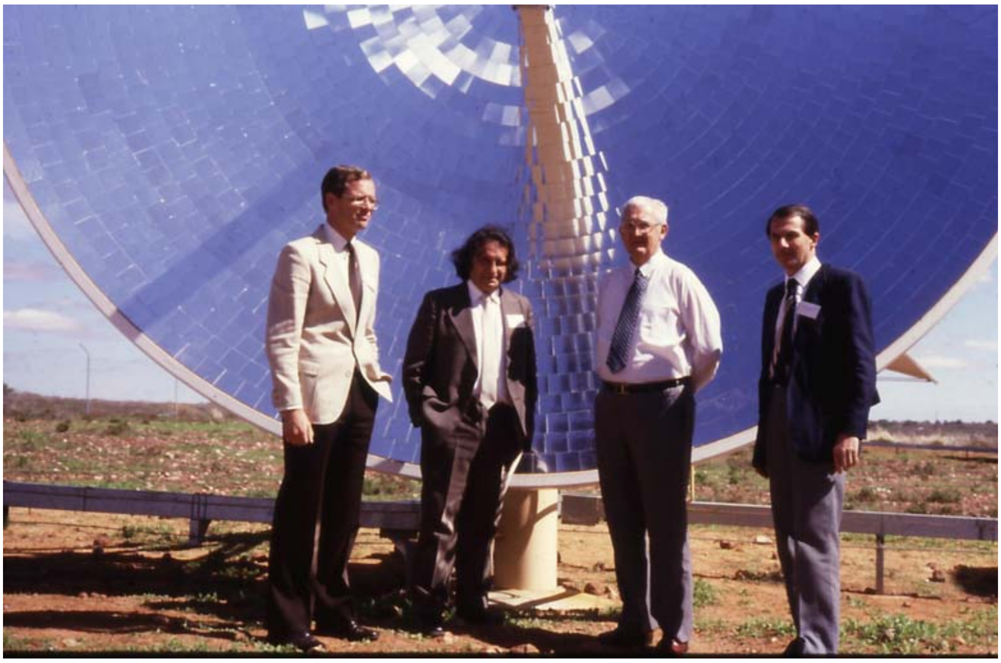
This station was designed and built in 1981 by Australian National University researchers with M$1.9 funding from the NSW Government. Fourteen tracking parabolic dishes of 5 metres diameter concentrated the sun onto thermal absorbers to heat water. The steam produced powered a reciprocating engine & generator. As the electricity was sold to the community, this was arguably the Worlds first commercial solar power station. In 1997 the station was converted to a concentrating photovoltaic system and ceased generating in January 2005.

The Institution of Engineers Australia
Country Energy
2006 - twenty fifth anniversary of construction

Photographs: (various sources)

Photo courtesy Solar Systems

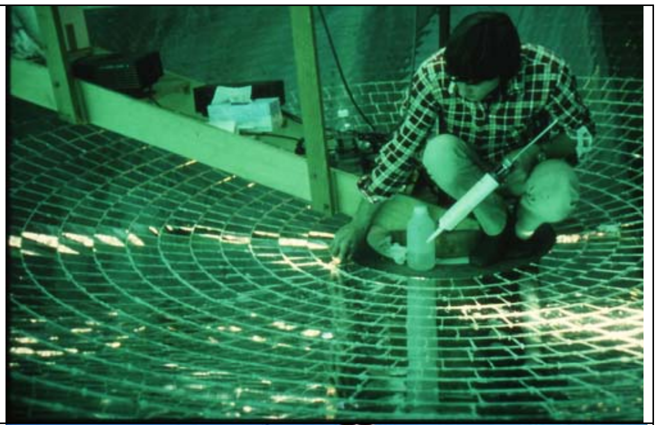
Photo courtesy Solar Systems



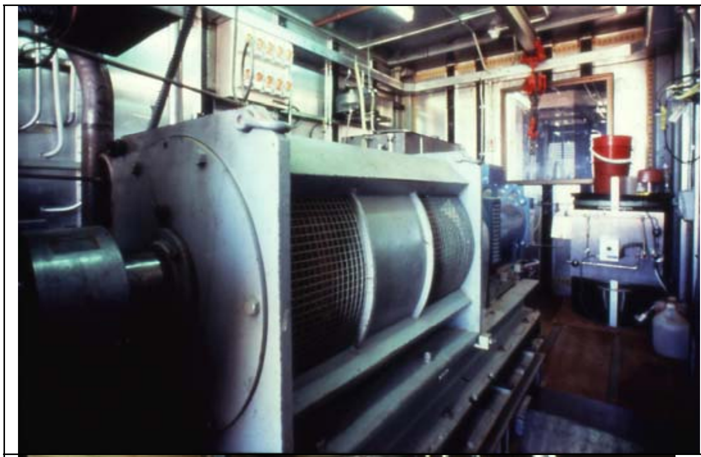
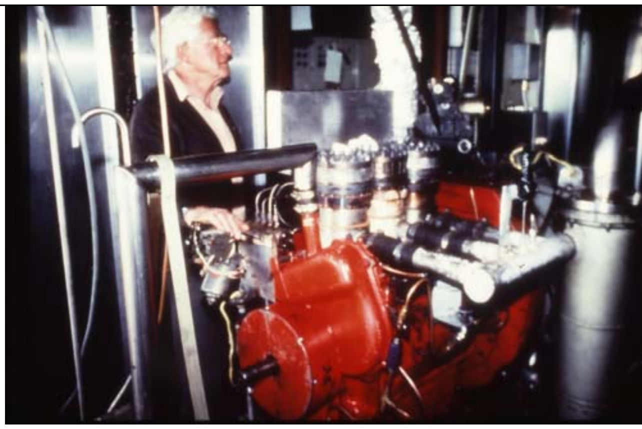
L-R Mr Ted Woodley, Assistant General Manager, Energy Authority of NSW
Prof Stephen Kaneff, Australian National University, The Hon Peter Cox MP, Minister for Energy and Technology, Professor John Glastonbury, University of Sydney -1986 Photo courtesy Mal Williams @ DEUS

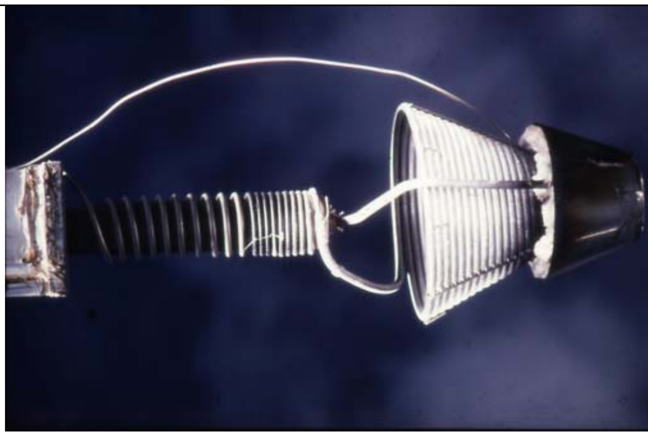
Recent Photo by Country Energy

Recent Photo by Country Energy



Constructing the Original Thermal System – Photos courtesy of Mal Williams at DEUS





Constructing the Original Thermal System – Photos courtesy of Mal Williams at DEUS

Owner Approval for Plaquing

Guy Chick/People/Country Energy

07/03/2006 10:29 AM

To
Chris Dalitz/People/Country Energy@COUNTRYENERGY
cc

SubjectRe: Fw: Historic Plaquing of White Cliffs Solar Power Station

Chris

Please recognise this response as my formal approval of the installation of the Engineering Marker

Thanks & regards

Guy

Guy Chick
Country Energy
Regional General Manager - Far West
PO Box 800 Broken Hill NSW 2880
Tel: 08 8082 5307
Fax: 08 8082 5444
Mob: 0417 297 993

Chris Dalitz/People/Country Energy

07/03/2006 09:17 AM

Hi Guy,
As discussed last evening, could you please indicate your formal approval, as the site owner, for a 'Historical Engineering Marker' to be placed at the White Cliffs Solar Power Station by IEAust.
Cheers !
Chris

Chris Dalitz
Manager Network Assets - Far West
160-162 Beryl Street
Broken Hill NSW 2880
PO Box 800 Broken Hill
Phone: (08) 8082 5881
Mobile: 0409 321 470